Abstract to Institute of Environmental Sciences, 42nd Annual Technical Meeting, May 12-17, 1996

Sub-ppb Oxygen Contaminant Detection in Semi-Conductor Processing

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Abstract

Gaseous contaminants such as oxygen, water vapor, nitrogen and hydrocarbons are often present in the processing environment in semiconductor device fabrication and in containerless materials processing. The contaminants arise as a result of outgassing from hot surfaces or they may be part of the impurities in commercial ultra-high purity gases. Among these gaseous contaminants, oxygen is the most reactive and, therefore, has the most adverse effects on the end product. There has been an intense effort at the Jet Propulsion Laboratory to develop different types of oxygen sorbents to reduce oxygen concentration in a microgravity processing environment to sub-ppb (parts-per-billion) levels. Higher concentrations can lead to rapid surface oxide formation, hence reducing the quality of semiconductor devices. If the concentration of oxygen in a processing chamber at 1000 ^{o}C is in the ppb level, it will only take approximately 10 seconds for an oxide layer to form on the surface of a sample. The interaction of oxygen with the wafer surface can lead to the formation of localized defects in semi-conductor devices, hence decreasing the manufacturing yield. For example, efficient production of 64Mb RAM chips requires contaminations below ppb levels. This paper describes a technique for measuring trace quantities of oxygen contaminants by recording the monoatomic negative ions, 0-, using mass spectrometry. The 0^- formation from the e^-–O_2 interaction utilizes the electron dissociative attachment method that is greatly enhanced at the resonant energy (6.8 eV). The device combines a small gridded electron ionizer with a compact mass spectrometer. The concentrations of oxygen have been measured using the method of standard additions by diluting 0_2 in N_2 The lowest detection limit obtained was 1.2 kHz (0^- count rate) at a concentration of 10-’0, corresponding to 0.1 ppb.